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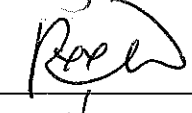
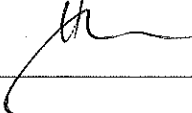
***Hydrogen Sulfide Removal by Biological Methods***

***(Final Report)***

**Research and Development Section  
Electrical & Mechanical Projects Division  
Drainage Services Department**

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## Executive Summary

The objectives of this Study are to review different biological odor removal technologies and to evaluate the possibilities of applying a variety of such technologies in the sewage treatment works in Hong Kong. A desktop study of biological odor removal technologies had been carried out through review of literature and commercially available products. Biofilter (BF) and biotrickling filters (BTF) are the focuses. Performances of selected BTFs in DSD were shown.

Biological odor treatment technologies are applicable for a wide range of pollutants including hydrogen sulfide ( $H_2S$ ) gas. Biological technologies for example bioscrubber is more suitable for  $H_2S$  removal in energy gas. BF and BTF technologies can be used under ambient pressure, and temperature, and are not energy- nor resource-intensive, and simple to operate. Generally speaking, biological  $H_2S$  treatment by BF and BTF is considered environmental friendly because less chemical is consumed when compared to chemical scrubber and impregnated activated carbon. Biological  $H_2S$  treatment does not generate secondary pollutants such as  $NO_x$  or wasted activated carbon. As a green technology, it can be well received by the general public.

When compared to other odor abatement technologies including physical-chemical and combustion, biological  $H_2S$  treatment with BF and BTF possess benefits of low operation cost and low maintenance. At moderate  $H_2S$  level, a study compared various odor abatement technologies found the operating cost is the lowest for BTF and followed closely by BF.

Treatment capability of  $H_2S$  can be expressed in Elimination Capacity (EC) in  $gH_2S/m^3.h$ . Important design considerations are empty bed residence time (EBRT), inlet  $H_2S$  level, EC and required removal efficiency (RE). Longer EBRT means a larger media bed for the deodorizing unit and therefore a larger footprint. At higher inlet  $H_2S$ , the use of a biological system with a higher EC for the same RE can result in a smaller unit.

The most noticeable disadvantages of biological  $H_2S$  treatment (both BF & BTF) are acclimation period required, limited ability to handle shock loads, subject to short circuiting and upsets, the low pH in blowdown. They may also require a final polishing step to meet very stringent exhaust air standard. A combined BTF+Activated carbon (BTF+AC) has been reported to achieve very high robustness in odor removal, but its operating cost will be significantly higher than a BTF-only system. A combined BTF+AC therefore becomes particularly desirable in the presence of sensitive neighbors.

In addition to engineered BF systems, open-bed type BF with very simple design had been installed in various sewage treatment facilities. They typically used low-cost tree-bark as the packing media. The outcome was perceived to be positive when the tree-bark media can be kept moist throughout the operation.

In design, the permissible inlet  $\text{H}_2\text{S}$  for BTF is generally higher than BF, BF could be selected when average is about  $\geq 10\text{ppmv}^1$ , and BTF for average  $\text{H}_2\text{S} \geq 20\text{ppmv}$ . In order to achieve similar  $\text{H}_2\text{S}$  removal, the required EBRT of BF is longer than that of BTF. Though a higher  $\text{H}_2\text{S}$  removal capacity is expected from a larger system (longer EBRT), there is no simple rule. A large fraction of BTF systems in DSD for average inlet  $\text{H}_2\text{S}$  of 20 ppmv, EBRT of 12-15 sec has been adopted. BF can have EBRT of 30 sec or more.

When the inlet level is high ( $>50\text{ppmv}$ ), EC is more important. Shatin STW inlet works (DO#1) BTF with design average  $\text{H}_2\text{S}$  20 ppmv, using biocoal as packing media, demonstrated remarkably good RE at average  $\text{H}_2\text{S}$  60 ppmv and achieved EC of  $15\text{gH}_2\text{S}/\text{m}^3\cdot\text{h}$ .

For the treatment of exceptionally high inlet  $\text{H}_2\text{S}$  (e.g.  $3000\text{ppmv}$ ), a BTF with ordinary packaging media will be enormous in size. BioAir Solutions LLC reported their proprietary structured packing media EcoBase<sup>TM</sup> can deliver a very high EC (for RE 99%, the EC is about  $100\text{gH}_2\text{S}/\text{m}^3\cdot\text{h}$ ). The system would be designed to operate with the foul air diluted to  $500\text{ppmv}$   $\text{H}_2\text{S}$  level for biological treatment.

On the other hand, performance reports of biological treatment of low inlet  $\text{H}_2\text{S}$  level ( $<5\text{ppmv}$ ) by BF or BTF were scarce in literature. In these cases, high EC is not a concern and EBRT becomes the limiting factor. Though EBRT as short as 2 sec had been reported in laboratory- and pilot-scale studies, such extreme EBRT is rare in full-scale operation.

Acclimation of biomass is important for the performance of biological  $\text{H}_2\text{S}$  treatment. They are reportedly not particularly capable of treating infrequent  $\text{H}_2\text{S}$  peaks or shock loads. Nonetheless, Ma Wan STW (DO#3) BTF using synthetic polypropylene (PP) as packing media demonstrated high RE of transient  $\text{H}_2\text{S}$  peaks (up to  $60\text{ppmv}$ ) which was 5 times the average level or 3 times the design average  $\text{H}_2\text{S}$ .

Biological  $\text{H}_2\text{S}$  treatment in Hong Kong has been tested to be positive. Good performances of BTF were apparent both in cases of treating consistent high- $\text{H}_2\text{S}$  (using biocoal as packing media) and removal of  $\text{H}_2\text{S}$  peaks (using PP). However, there had been few data of BF treating  $\text{H}_2\text{S}$  at relatively high level. Due to longer EBRT and limit of bed

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<sup>1</sup> ppmv is Parts per million by volume. For any gas, 100% is 1,000,000 ppmv. For example, 1%  $\text{H}_2\text{S}$  gas is 10,000 ppmv. The relation between  $\text{mg}/\text{m}^3$  and ppmv depends on the Molecular weight (MW) of the gas. For  $\text{H}_2\text{S}$  gas, at standard condition, 1 ppmv  $\text{H}_2\text{S}$  is about  $1.4\text{mg H}_2\text{S}/\text{m}^3$ .

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depth for BF, the land use requirement of BF is generally higher. Further, BTF is likely to be more capable of handling higher inlet  $\text{H}_2\text{S}$  concentration. For BF, there is a concern of its lack of operational control. As a result, BTF is normally preferred when design average inlet  $\text{H}_2\text{S}$  is 20ppmv or above.

Based on the findings of this desktop study, it is recommended to continue the use of biological  $\text{H}_2\text{S}$  treatment unless the inlet  $\text{H}_2\text{S}$  is very low for which activated carbon filter may suffice. When the average is at or above 20ppmv, BTF is favored over BF.

A combined BTF+AC system can provide higher robustness than a BTF-only system. It can be recommended when the exhaust air is close to sensitive neighbors. The operating cost of the combined system will be higher than BTF-only.

Retrofitting of wet-scrubber using caustic ( $\text{NaOH}$ ) and bleach solution to BTF has been reported and they have been reported to give successful and very positive  $\text{H}_2\text{S}$  treatment performance. Due to the low operating cost of BTF when compared to the high chemical cost for chemical scrubber, the possibility of similar retrofitting work can be explored.